Introduction

The Thermochron is built on two technologies, a computer chip enclosed in a stainless steel can (called an iButton), and a communications protocol (called 1-Wire). The iButton is a standalone instrument with a battery and protective housing. Once it is programmed it will run for a long time without attention, and without any external connections. The 1-Wire protocol is used to command the iButton and to retrieve data that is stored on the computer chip inside.

A Thermochron is a special iButton that has a temperature sensor, a clock, and a memory. The Thermochron can be programmed to record temperature readings at a desired interval. The temperatures can later be retrieved along with the time of each reading.

Every iButton device has a unique address stamped on the face of the can. This address is also encoded in the computer chip and accompanies any data read from the device. You can always trace which device you data came from using this address.

Communicating with a Thermochron requires a 1-Wire interface to your computer and the iButton Viewer software. The following documentation will guide you in installing the software, programming the Thermochrons, and retrieving the temperature data.

Installation

Installation of the iButton Viewer software is straightforward. The install program will guide you through the installation process. Simply run the install program and have you 1-Wire interface hardware ready to connect to your computer when prompted to do so. Once the software is installed you will be ready to communication with your iButton Thermochron.

Physical connections

The physical connection between your computer and a Thermochron requires two pieces of hardware, a 1-Wire adapter and an iButton probe. The 1-Wire adapter plugs into your computer either through a USB port or a RS-232 serial port. The iButton probe connects to the 1-Wire adapter to the Thermochron.

Connect the iButton probe to the 1-Wire adapter using the RJ-11 cable.

Plug the 1-Wire adapter into the correct port on your computer.

Place Thermochron in the iButton probe.

Running the iButton Viewer

Click on the iButton Viewer icon to run the program. Be sure the 1-Wire adapter is connected to the computer when you start the software. On the left side of the screen is a list the addresses of all 1-Wire devices connected to the computer. The first address on the list will be the 1-Wire adapter. The next numbers will be the Thermochron you have connected to the iButton probe. The list will allow you to bring up a screen to communicate with your Thermochron.

The Thermochron Viewer has three Tab panels: the Wizard, Mission Results, and Status panels. The Status tab shows the current state of the Thermochron. Fields indicate the sampling rate, the number of recorded samples, the current time and other information. Select the help menu for a description of the fields. The other two Tab panels are described in the following two sections.
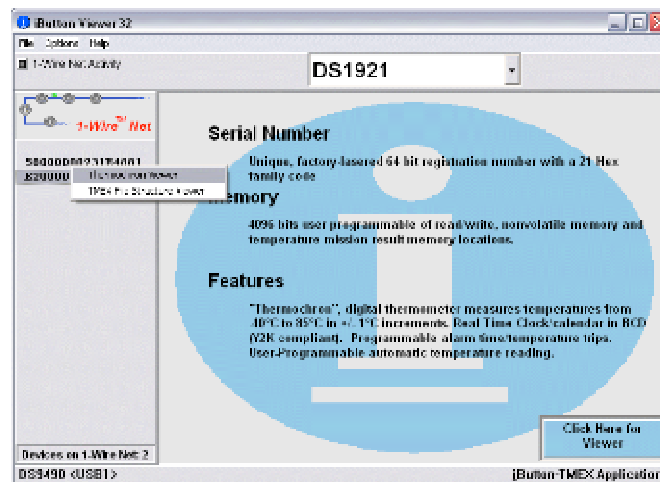
Click on the address of your Thermochron and select Thermochron Viewer.
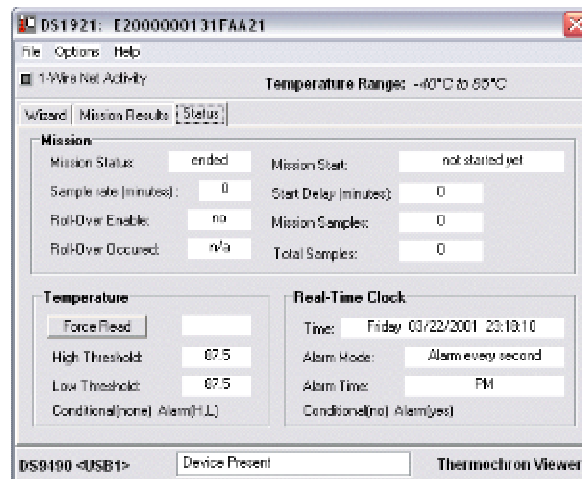

The Status Tab will show the current state of the Thermochron

Programming the Thermochron

Programming the Thermochron is called "missioning". With this process you will tell the Thermochron how often to record the temperature, when to start recording and other parameters. Once the thermochron is disconnected from the interface, it will continue recording the temperature readings, following the decisions you have made. Set the parameter on each page and click the Next button.
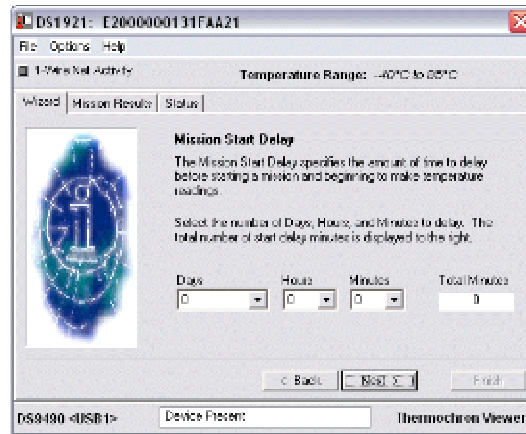
To set these parameters, start the iButton Viewer and select the Wizard tab. The description below will indicate the most common options. For a more complete description of each panel of the Wizard or to use other options, select Help from the menu bar.
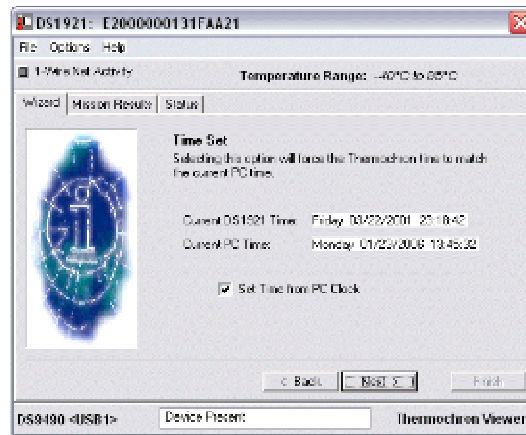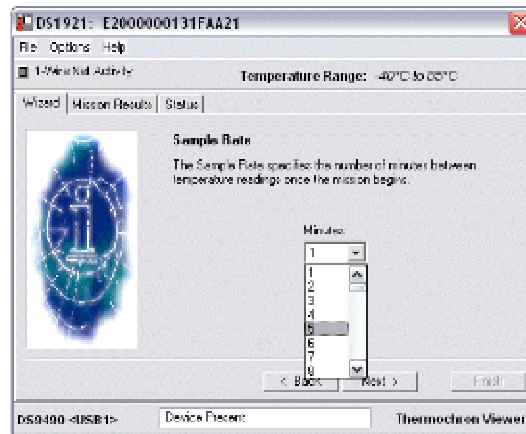

The Thermochron clock will be set to match the time on your PC.
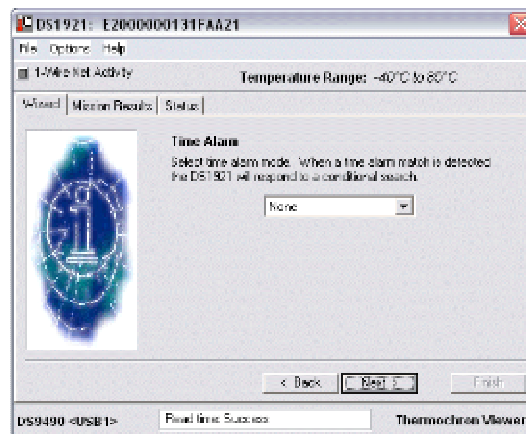
Leave the Time Alarm set to None.

Select the time to delay before the first temperature reading is recorded.
If you are programming more than one Thermochron, this setting can be used to assure that they start recording at the same time.

Select the time between temperature readings. The typical Thermochron records about 2000 readings, so more time between readings will allow the Thermochron to record over a longer period.
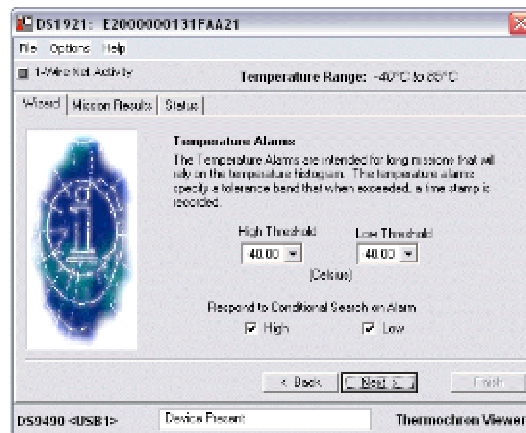
For recording a time series of temperature, ignore the Temperature Alarms.
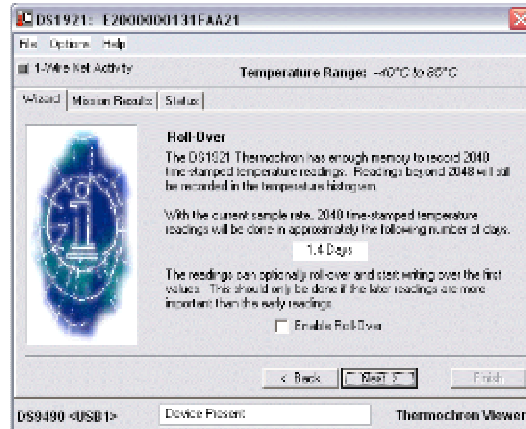
The Roll –Over panel will indicate how long the Thermochron will record based upon the Sample Rate. If you enable Rollover, once the Thermochron has filled up its memory it will begin to overwrite the earlier readings with new readings.
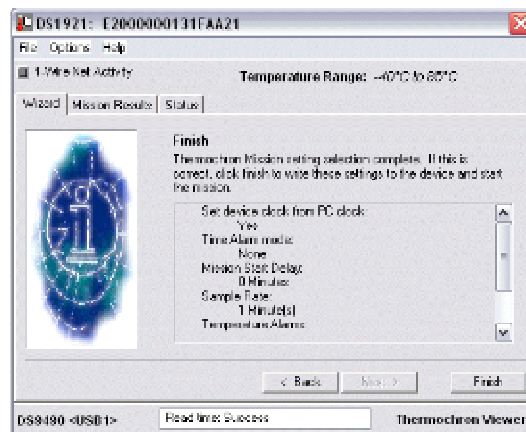
Clicking the Finish button will program the Thermochron with your parameters and begin the mission. You may get a warning if there is a mission already running on the Thermochron.

Retrieving Thermochron Data

The Mission Results tab of the Thermochron Viewer will retrieve the data from the recorded temperature readings and allow you to save or view them. When you select the Mission Results tab, the data will automatically be transferred from the Thermochron. Wait a few seconds until the data appears in the results windows. The description below will indicate the most common options for viewing and saving the Thermochron data. A later section will illustrate how to import the temperature readings into other programs for analysis. For a more complete description of all capabilities or to use other options, select Help from the menu bar.
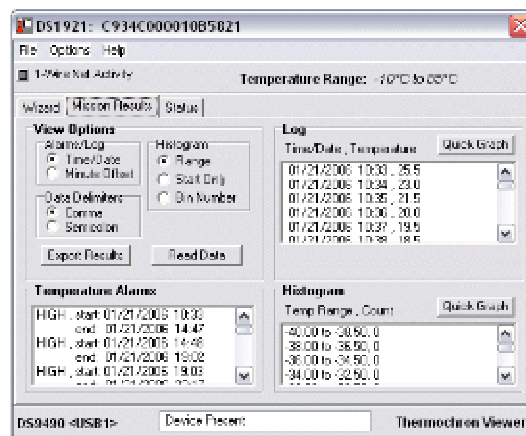
The Log window lists all the temperature readings recorded by the Thermochron.
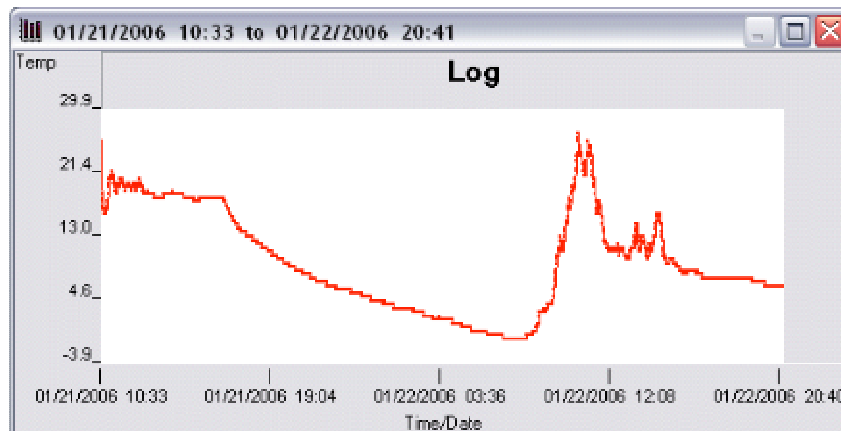
The Quick Graph button of the Log window will draw a graph of the entire mission.
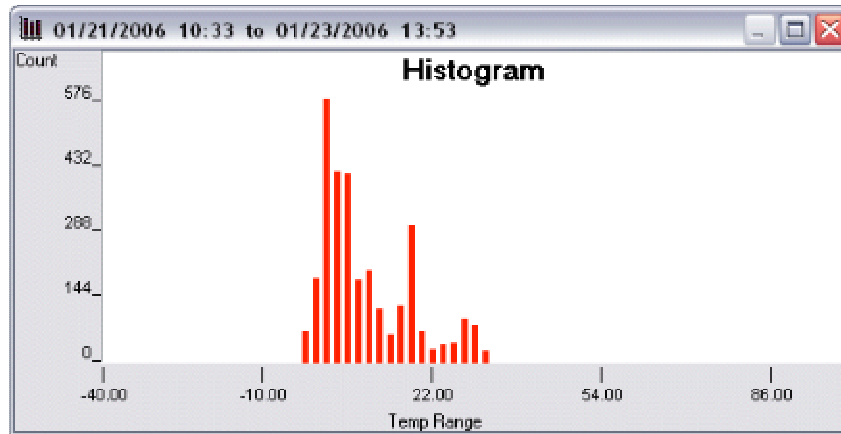
The Quick Graph button of the Histogram window will draw a histogram of the entire mission.
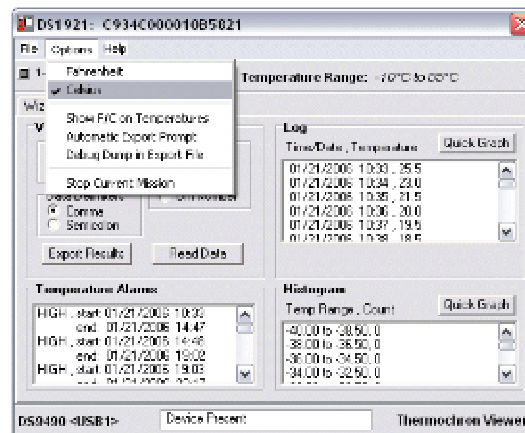
Select whether you want Fahrenheit of Celsius temperatures reported.
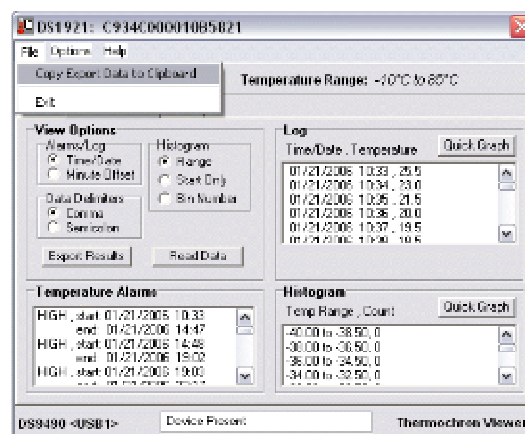
Click the Export Data button to save information and temperature readings to a text file. The Copy Export Data to Clipboard allows you to switch programs and paste the data directly into the program of your choice.

Importing Thermochron Data

Once you have saved your Thermochron data to a text file or to the Clipboard, you can use external programs to review and analyze the data.
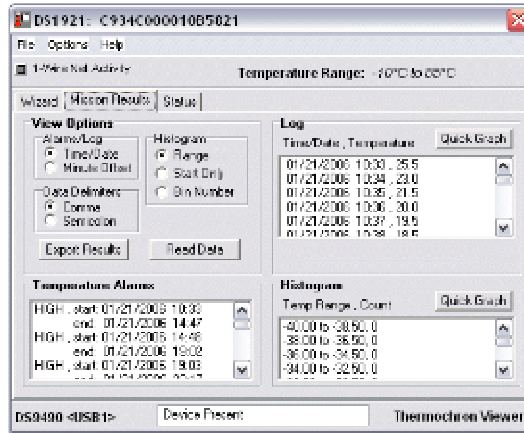
 Click the Export Data button to save information and temperature readings to a text file.

When you export data be sure to give the file a name that will help you associate the data with a part of your experiment. For example if you have a thermochron in the open air you can name the file AIR.TXT. The thermochron serial number will be in the data file to help you keep track of your data.

The text file can be imported into other software packages (usually a spreadsheet program) such as Microsoft Works or Excel. Use the import function to have the data fields separated into different columns. Several files can be imported into the same spreadsheet to compare the data from multiple thermochrons.

The exported file will have five sections. The first section indicates the thermochron
serial number and the time it was downloaded.

```
DS1921:  D10000001117F521
Download at: 5/8/2005 2:33:18 PM
```

The Mission State section will have the information about how the thermochron was
programmed. This includes the time between samples and the time of the first sample

```
Mission State
-------------
Mission is in progress
Sample rate: 180 minute(s)
Roll-Over Enabled: no
Roll-Over Occured: n/a
Mission Start time:  09/19/2004  01:00
Mission Start delay: 0 minute(s)
Mission Samples: 1853
Device total samples: 83250
Temperatures displayed in: (Fahrenheit)
High Threshold: -40.0
Low Threshold: -40.0
Temperature threshold alarm state: Conditional(H,L)
Alarm(H)
Current Real-Time Clock from DS1921: Sunday  05/08/2005
14:37:04
Current PC Time: Sunday  05/08/2005  14:34:49
Time Alarm mode: Alarm weekly
Alarm Time: Sunday 00:00:00
Alarm Time state: Conditional(yes)  Alarm(yes)
```

The Temperature Alarms section will list the temperature alarms. This mode of
operations is not covered in this document.

```
Temperature Alarms
------------------
Format: [(HIGH/LOW), Time/Date range]
HIGH ,  09/19/2004  01:00  to  10/20/2004  19:00
HIGH ,  10/20/2004  22:00  to  11/21/2004  16:00
HIGH ,  11/21/2004  19:00  to  12/23/2004  13:00
HIGH ,  12/23/2004  16:00  to  01/24/2005  10:00
HIGH ,  01/24/2005  13:00  to  02/25/2005  07:00
HIGH ,  02/25/2005  10:00  to  03/29/2005  04:00
HIGH ,  03/29/2005  07:00  to  04/30/2005  01:00
HIGH ,  04/30/2005  04:00  to  05/08/2005  13:00
```

The Temperature Histogram section lists the histogram of the recorded data. The number of times the temperature reading fell within each temperature range is listed.

```
Temperature Histogram
---------------------
Format: [Temp Range , Count] (Fahrenheit)
-11.20 to -8.50, 0
-7.60 to -4.90, 1
-4.00 to -1.30, 1
-0.40 to 2.30, 1
3.20 to 5 .90, 2
6.80 to 9 .50, 8
10.40 to 13.10, 11
14.00 to 16.70, 21
17.60 to 20.30, 42
.
.
.
```

The Log Data section lists each temperature reading. The data, time, and recorded temperature are listed.

```
Log Data
--------
Format: [Time/Date , Temperature] (Fahrenheit)
 09/19/2004  0 1:00 , 65.3
 09/19/2004  0 4:00 , 2.3
 09/19/2004  0 7:00 , 10.4
 09/19/2004  1 0:00 , -2.2
 09/19/2004  1 3:00 , 71.6
 09/19/2004  1 6:00 , 71.6
 09/19/2004  1 9:00 , 71.6
 09/19/2004  2 2:00 , 71.6
 09/20/2004  0 1:00 , 70.7
 09/20/2004  0 4:00 , 70.7
 09/20/2004  0 7:00 , 69.8
.
.
.
```

Importing Thermochron Data into Excel

If you are using Excel, there is a menu option that allows a quick method of importing data from several thermochrons into a single spreadsheet.
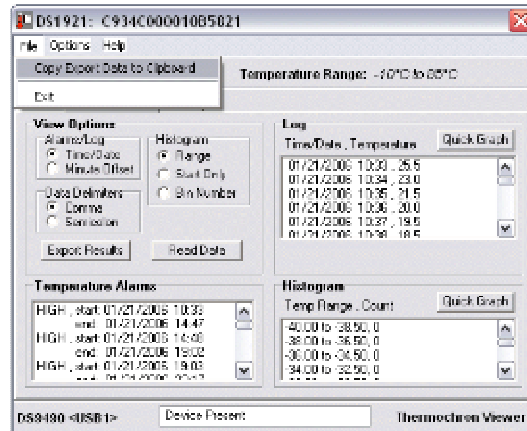
Use the Copy Export Data to Clipboard menu option from the iButton Viewer. This will hold the data in memory and you can Paste it into Excel directly. Create a new blank spread sheet and Paste the data into any column. To work with the Log Data section, first delete all the rows in the other data sections.
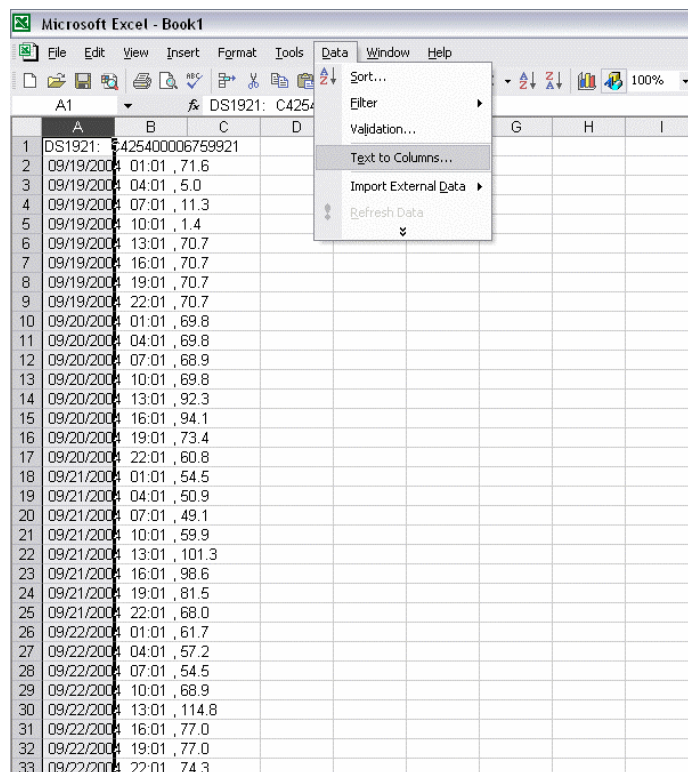
Then select the Text to Columns item from the Data menu.
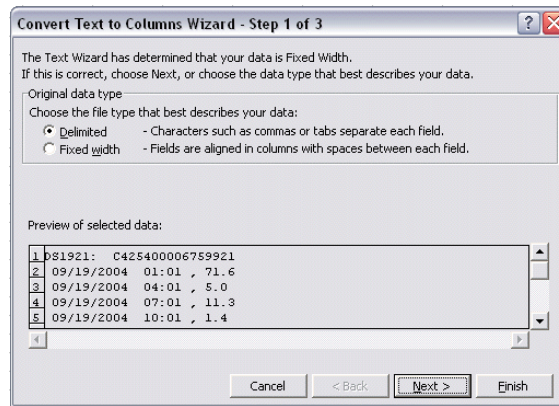
Select the Delimited option to indicate that text characters separate the data fields.
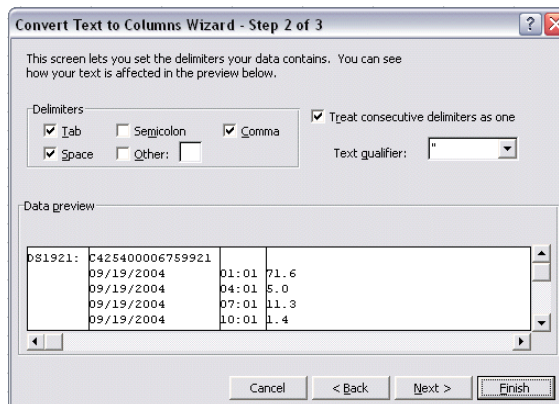
Select Space and Comma as delimiters and the data fields will be properly separated.

You will end up with the Date, Time, and Temperature in separate columns. You can now enter a label above the column to indicate what the data represents. You can repeat the steps by pasting the data from another thermochron into the same spreadsheet and Convert Text to Columns.

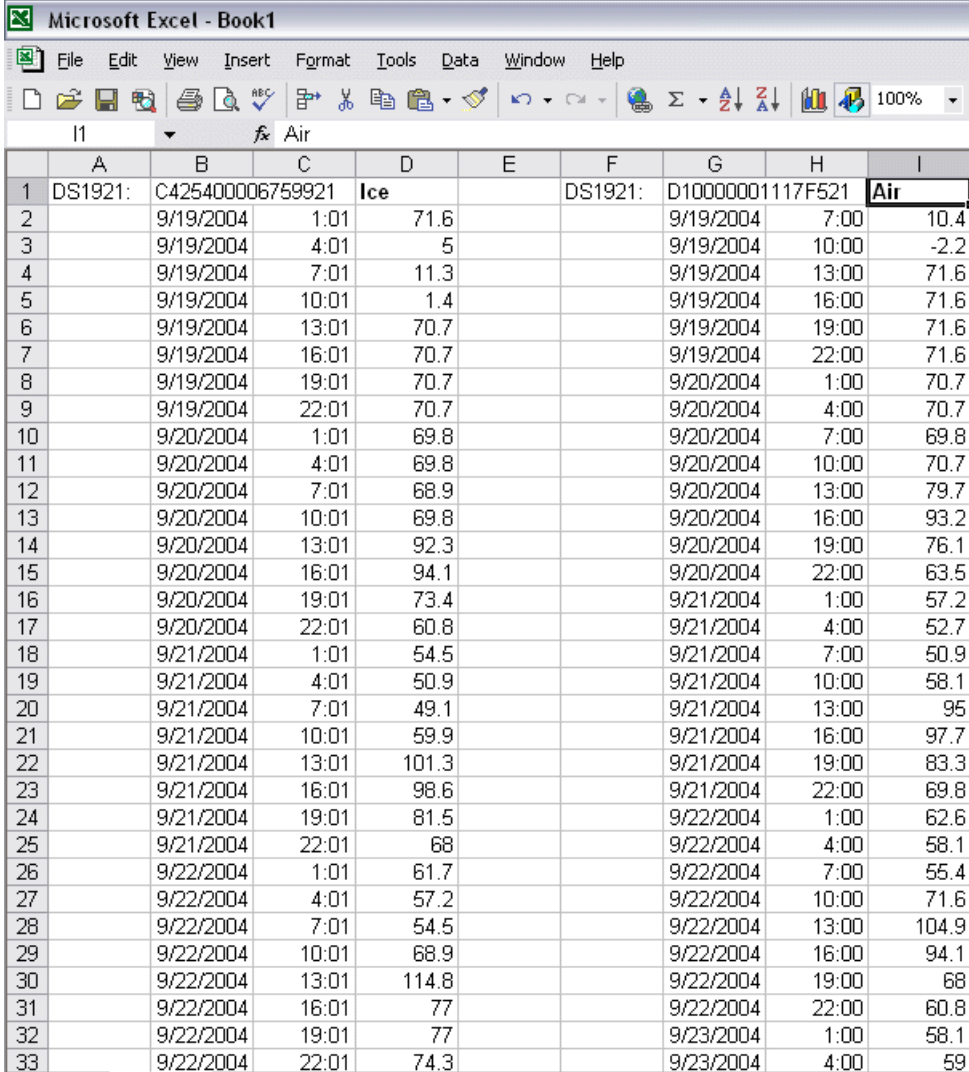|	A	B	C	D	E	F	G	H	I
1	DS1921:	C425400006759921		Ice		DS1921:	D10000001117F521		Air
2		9/19/2004	1:01	71.6			9/19/2004	7:00	10.4
3		9/19/2004	4:01	5			9/19/2004	10:00	-2.2
4		9/19/2004	7:01	11.3			9/19/2004	13:00	71.6
5		9/19/2004	10:01	1.4			9/19/2004	16:00	71.6
6		9/19/2004	13:01	70.7			9/19/2004	19:00	71.6
7		9/19/2004	16:01	70.7			9/19/2004	22:00	71.6
8		9/19/2004	19:01	70.7			9/20/2004	1:00	70.7
9		9/19/2004	22:01	70.7			9/20/2004	4:00	70.7
10		9/20/2004	1:01	69.8			9/20/2004	7:00	69.8
11		9/20/2004	4:01	69.8			9/20/2004	10:00	70.7
12		9/20/2004	7:01	68.9			9/20/2004	13:00	79.7
13		9/20/2004	10:01	69.8			9/20/2004	16:00	93.2
14		9/20/2004	13:01	92.3			9/20/2004	19:00	76.1
15		9/20/2004	16:01	94.1			9/20/2004	22:00	63.5
16		9/20/2004	19:01	73.4			9/21/2004	1:00	57.2
17		9/20/2004	22:01	60.8			9/21/2004	4:00	52.7
18		9/21/2004	1:01	54.5			9/21/2004	7:00	50.9
19		9/21/2004	4:01	50.9			9/21/2004	10:00	58.1
20		9/21/2004	7:01	49.1			9/21/2004	13:00	95
21		9/21/2004	10:01	59.9			9/21/2004	16:00	97.7
22		9/21/2004	13:01	101.3			9/21/2004	19:00	83.3
23		9/21/2004	16:01	98.6			9/21/2004	22:00	69.8
24		9/21/2004	19:01	81.5			9/22/2004	1:00	62.6
25		9/21/2004	22:01	68			9/22/2004	4:00	58.1
26		9/22/2004	1:01	61.7			9/22/2004	7:00	55.4
27		9/22/2004	4:01	57.2			9/22/2004	10:00	71.6
28		9/22/2004	7:01	54.5			9/22/2004	13:00	104.9
29		9/22/2004	10:01	68.9			9/22/2004	16:00	94.1
30		9/22/2004	13:01	114.8			9/22/2004	19:00	68
31		9/22/2004	16:01	77			9/22/2004	22:00	60.8
32		9/22/2004	19:01	77			9/23/2004	1:00	58.1
33		9/22/2004	22:01	74.3			9/23/2004	4:00	59

You now have the data from two thermochrons side-by-side.

|	A	B	C	D	E	F	G	H	I
1	DS1921:	C425400006759921	Ice			DS1921:	D10000001117F521		Air
2		9/19/2004	1:01	71.6			9/19/2004	7:00	10.4
3		9/19/2004	4:01	5			9/19/2004	10:00	-2.2
4		9/19/2004	7:01	11.3			9/19/2004	13:00	71.6
5		9/19/2004	10:01	1.4			9/19/2004	16:00	71.6
6		9/19/2004	13:01	70.7			9/19/2004	19:00	71.6
7		9/19/2004	16:01	70.7			9/19/2004	22:00	71.6
8		9/19/2004	19:01	70.7			9/20/2004	1:00	70.7
9		9/19/2004	22:01	70.7			9/20/2004	4:00	70.7
10		9/20/2004	1:01	69.8			9/20/2004	7:00	69.8
11		9/20/2004	4:01	69.8			9/20/2004	10:00	70.7
12		9/20/2004	7:01	68.9			9/20/2004	13:00	79.7
13		9/20/2004	10:01	69.8			9/20/2004	16:00	93.2
14		9/20/2004	13:01	92.3			9/20/2004	19:00	76.1
15		9/20/2004	16:01	94.1			9/20/2004	22:00	63.5
16		9/20/2004	19:01	73.4			9/21/2004	1:00	57.2
17		9/20/2004	22:01	60.8			9/21/2004	4:00	52.7
18		9/21/2004	1:01	54.5			9/21/2004	7:00	50.9
19		9/21/2004	4:01	50.9			9/21/2004	10:00	58.1
20		9/21/2004	7:01	49.1			9/21/2004	13:00	95
21		9/21/2004	10:01	59.9			9/21/2004	16:00	97.7
22		9/21/2004	13:01	101.3			9/21/2004	19:00	83.3
23		9/21/2004	16:01	98.6			9/21/2004	22:00	69.8
24		9/21/2004	19:01	81.5			9/22/2004	1:00	62.6
25		9/21/2004	22:01	68			9/22/2004	4:00	58.1
26		9/22/2004	1:01	61.7			9/22/2004	7:00	55.4
27		9/22/2004	4:01	57.2			9/22/2004	10:00	71.6
28		9/22/2004	7:01	54.5			9/22/2004	13:00	104.9
29		9/22/2004	10:01	68.9			9/22/2004	16:00	94.1
30		9/22/2004	13:01	114.8			9/22/2004	19:00	68
31		9/22/2004	16:01	77			9/22/2004	22:00	60.8
32		9/22/2004	19:01	77			9/23/2004	1:00	58.1
33		9/22/2004	22:01	74.3			9/23/2004	4:00	59

If the thermochrons started recording at different times you can remove the data from some readings to get the rows to represent the data recorded at a particular time.

	A	B	C	D	E	F	G	H	I
1		Date	Time	Ice	Air				
2		9/19/2004	7:01	11.3	10.4				
3		9/19/2004	10:01	1.4	-2.2				
4		9/19/2004	13:01	70.7	71.6				
5		9/19/2004	16:01	70.7	71.6				
6		9/19/2004	19:01	70.7	71.6				
7		9/19/2004	22:01	70.7	71.6				
8		9/20/2004	1:01	69.8	70.7				
9		9/20/2004	4:01	69.8	70.7				
10		9/20/2004	7:01	68.9	69.8				
11		9/20/2004	10:01	69.8	70.7				
12		9/20/2004	13:01	92.3	79.7				
13		9/20/2004	16:01	94.1	93.2				
14		9/20/2004	19:01	73.4	76.1				
15		9/20/2004	22:01	60.8	63.5				
16		9/21/2004	1:01	54.5	57.2				
17		9/21/2004	4:01	50.9	52.7				
18		9/21/2004	7:01	49.1	50.9				
19		9/21/2004	10:01	59.9	58.1				
20		9/21/2004	13:01	101.3	95				
21		9/21/2004	16:01	98.6	97.7				
22		9/21/2004	19:01	81.5	83.3				
23		9/21/2004	22:01	68	69.8				
24		9/22/2004	1:01	61.7	62.6				
25		9/22/2004	4:01	57.2	58.1				
26		9/22/2004	7:01	54.5	55.4				
27		9/22/2004	10:01	68.9	71.6				
28		9/22/2004	13:01	114.8	104.9				
29		9/22/2004	16:01	77	94.1				
30		9/22/2004	19:01	77	68				
31		9/22/2004	22:01	74.3	60.8				
32		9/23/2004	1:01	72.5	58.1				
33		9/23/2004	4:01	70.7	59				

Remove the extra Data and Time columns and you have a nice spreadsheet with data from multiple thermochrons.
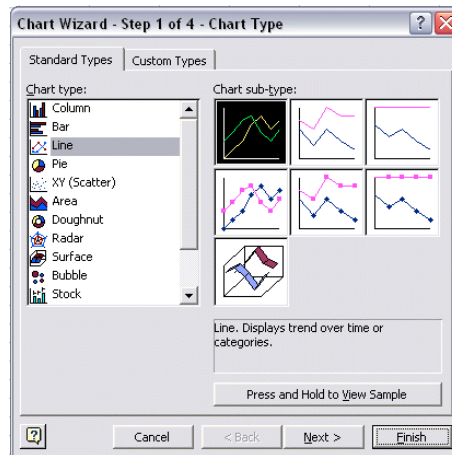
Select an interesting portion of the data and use the Chart Wizard to create a Line graph of the experiment.
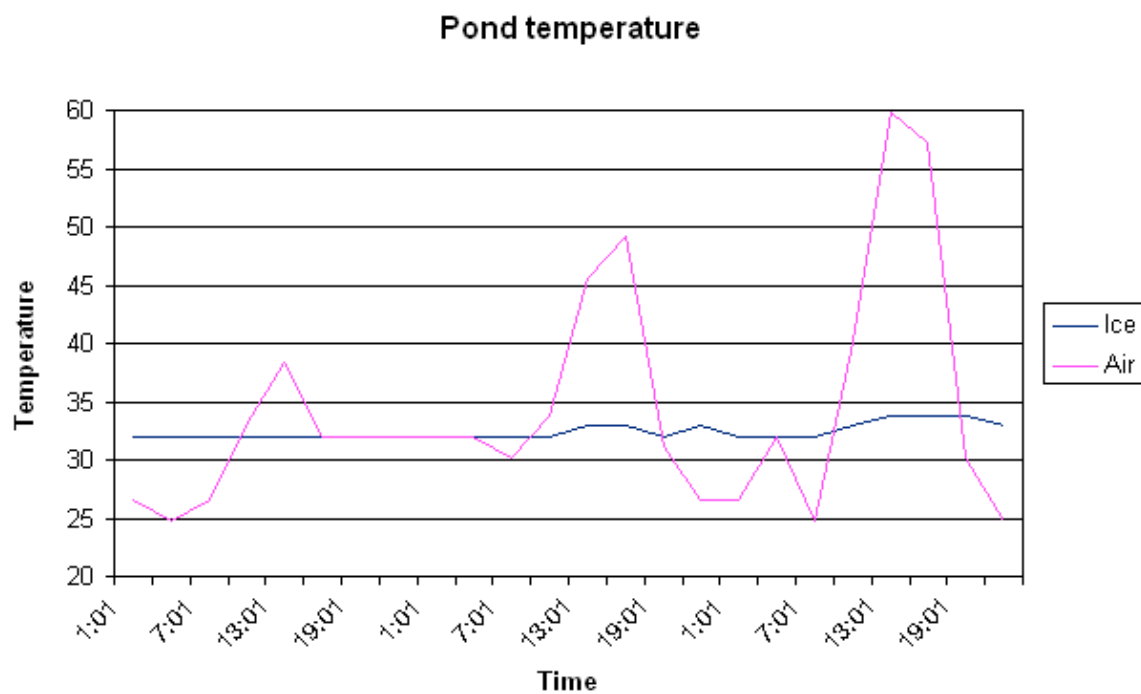
Pond temperature

In this example notice that the temperature of the ice remains nearly the same as the air temperature rises and falls. Cool.